Searching for low-frequency emission from star-exoplanet interactions

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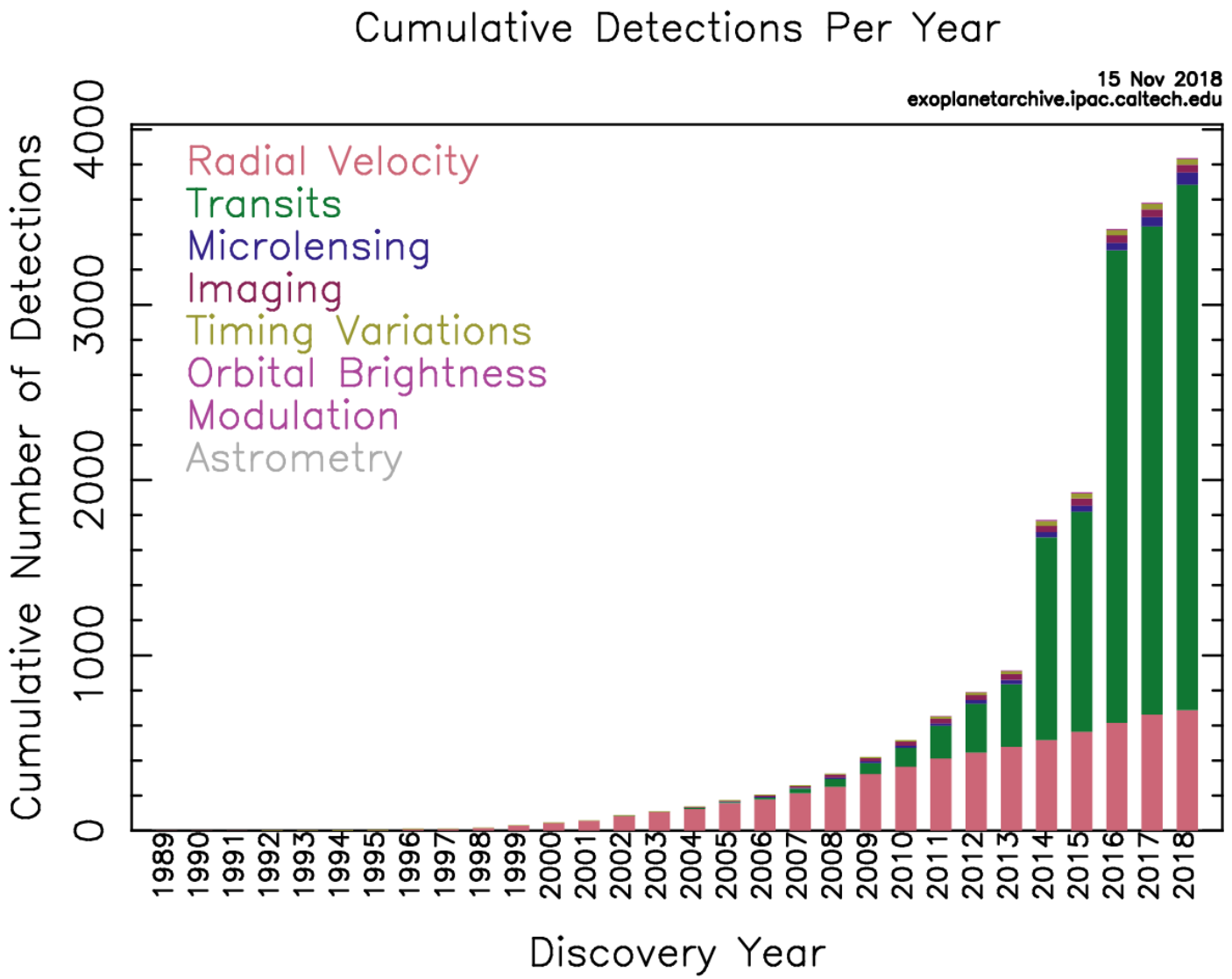
Radio Astronomy Research

WHY RADIO?



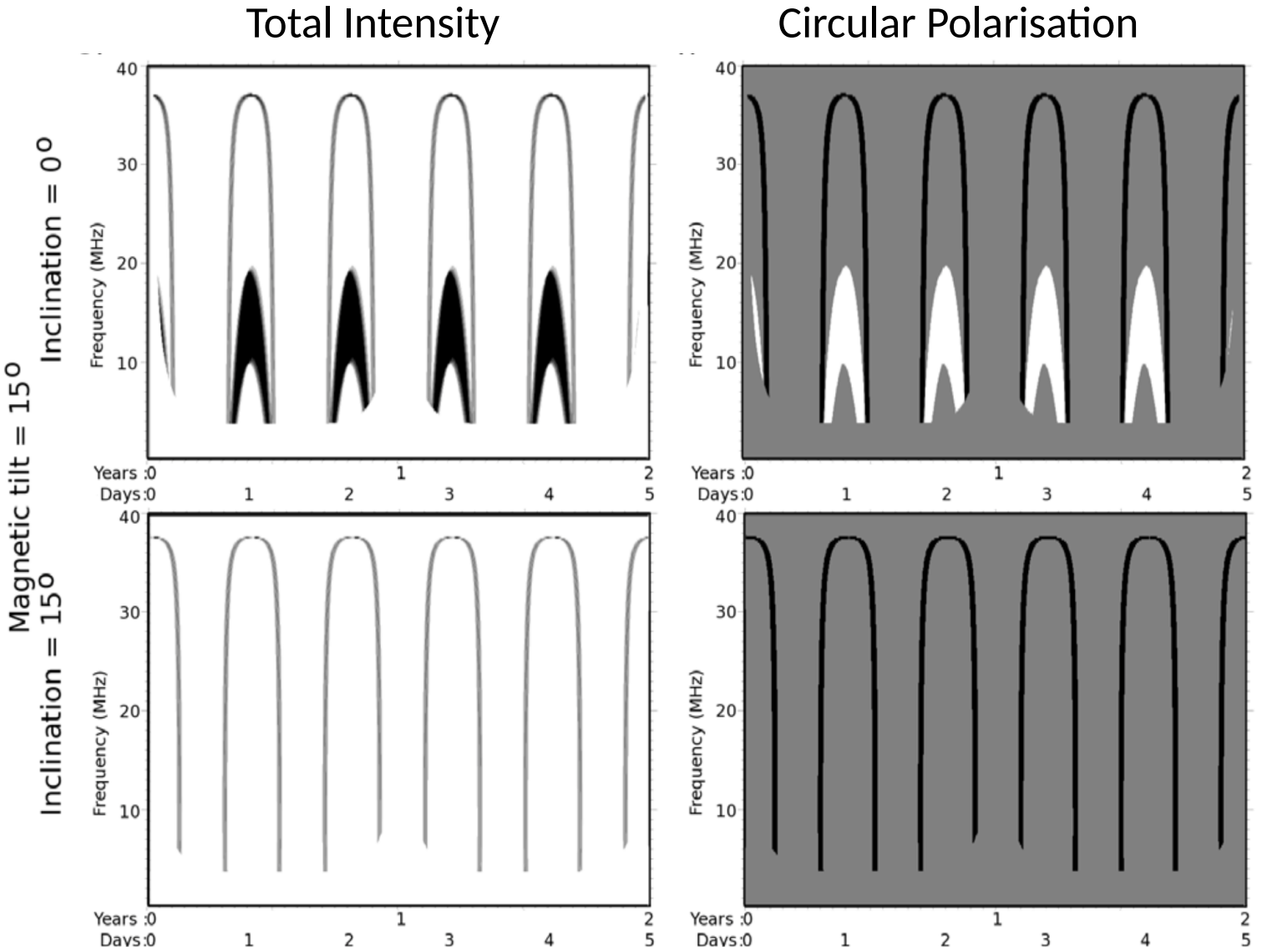
Magnetic field strength for planet

Estimate of planet interior composition

Assessing long-term ‘habitability’

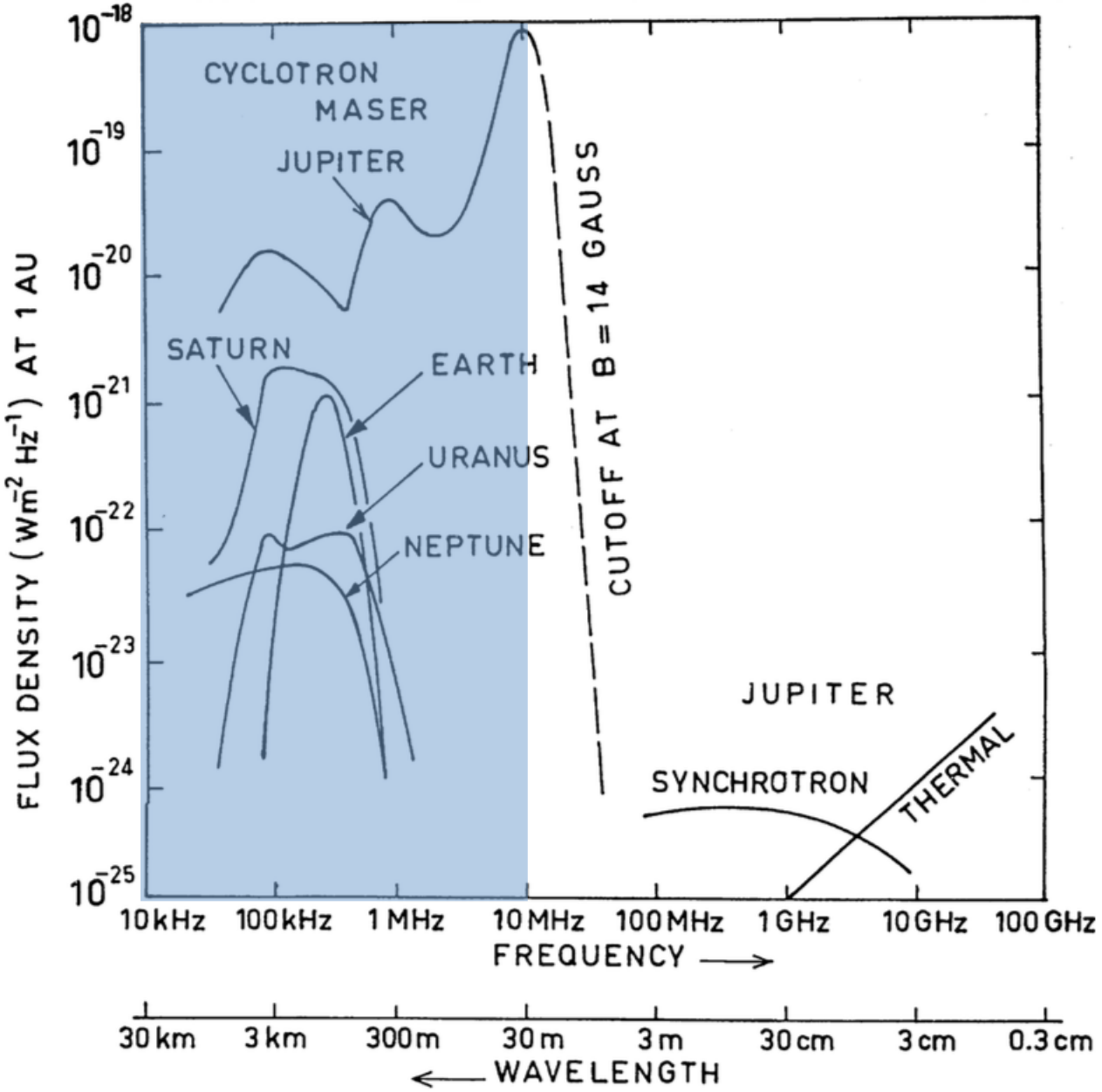
VARIABILITY OF RADIO IMPORTANT!

Orbital + rotational periods as well as inclinations of axes



Hess et al. (2011)

SOLAR SYSTEM PLANETS



All gas giants and the Earth have strong cyclotron maser emission.

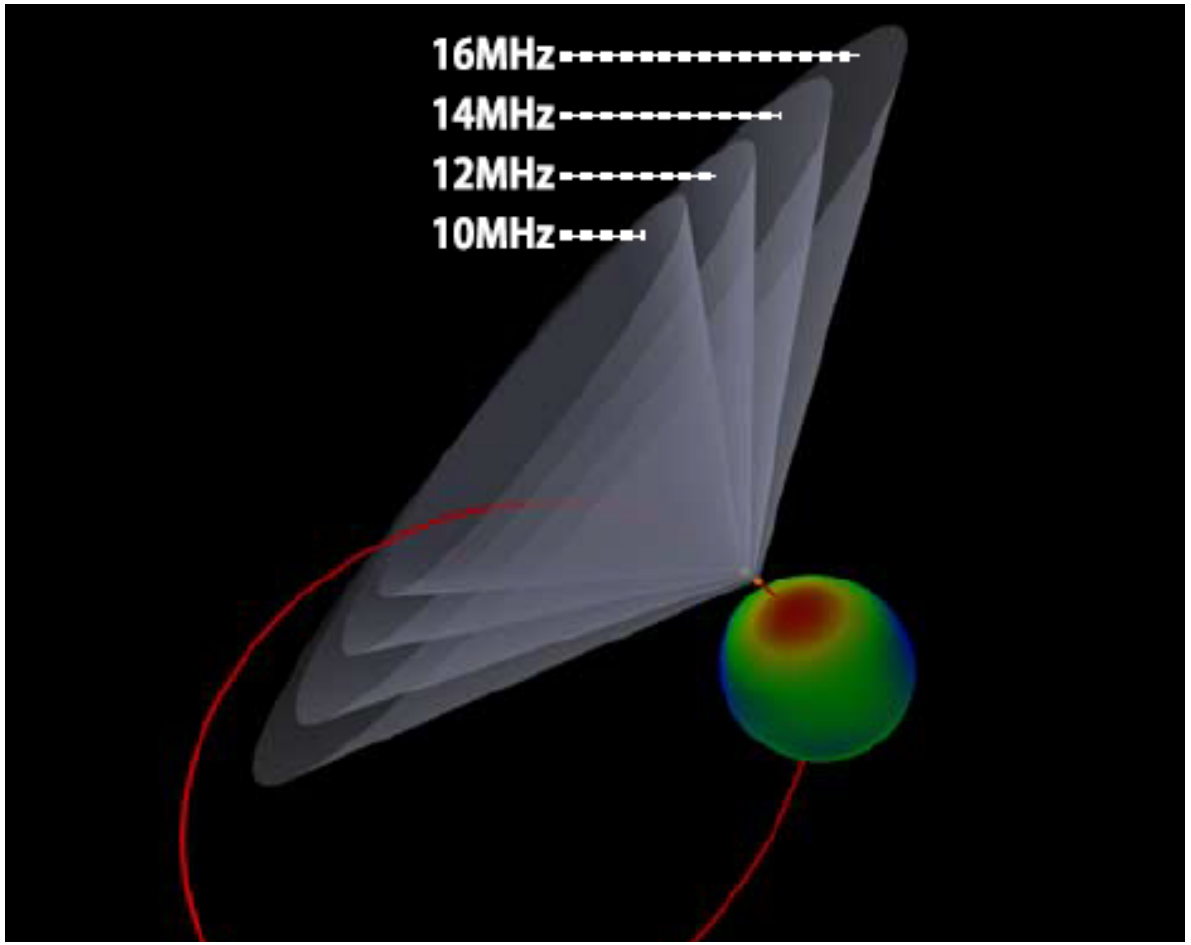
Bastian et al. (2000)

IMPORTANT CHARACTERISTICS OF EMISSION

Emission frequency = cyclotron frequency

$$\nu_{ce} = (B)\ 2.8\ \text{MHz}$$

Emission is highly circularly polarised



Can we detect similar emission for exoplanets?

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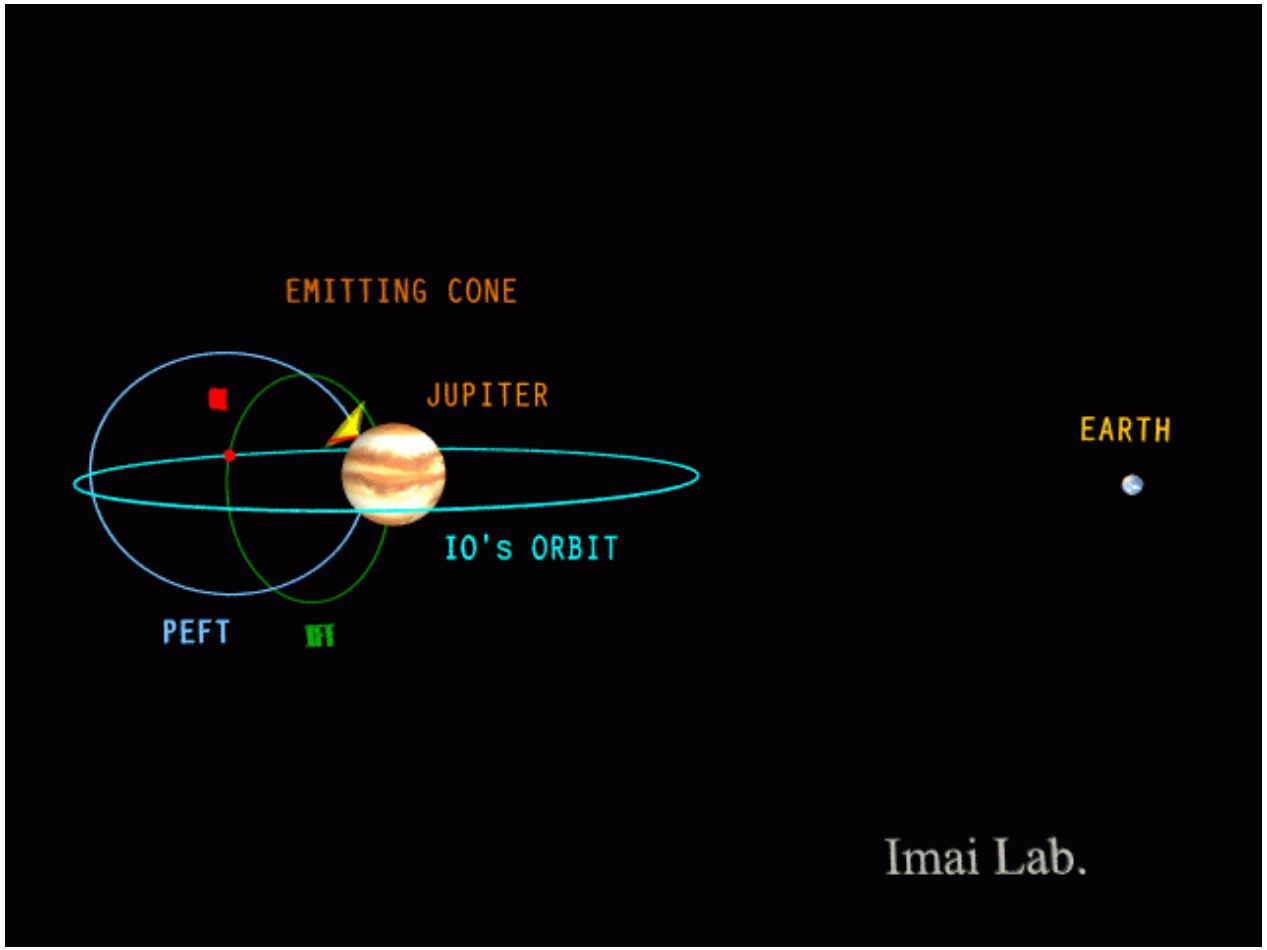
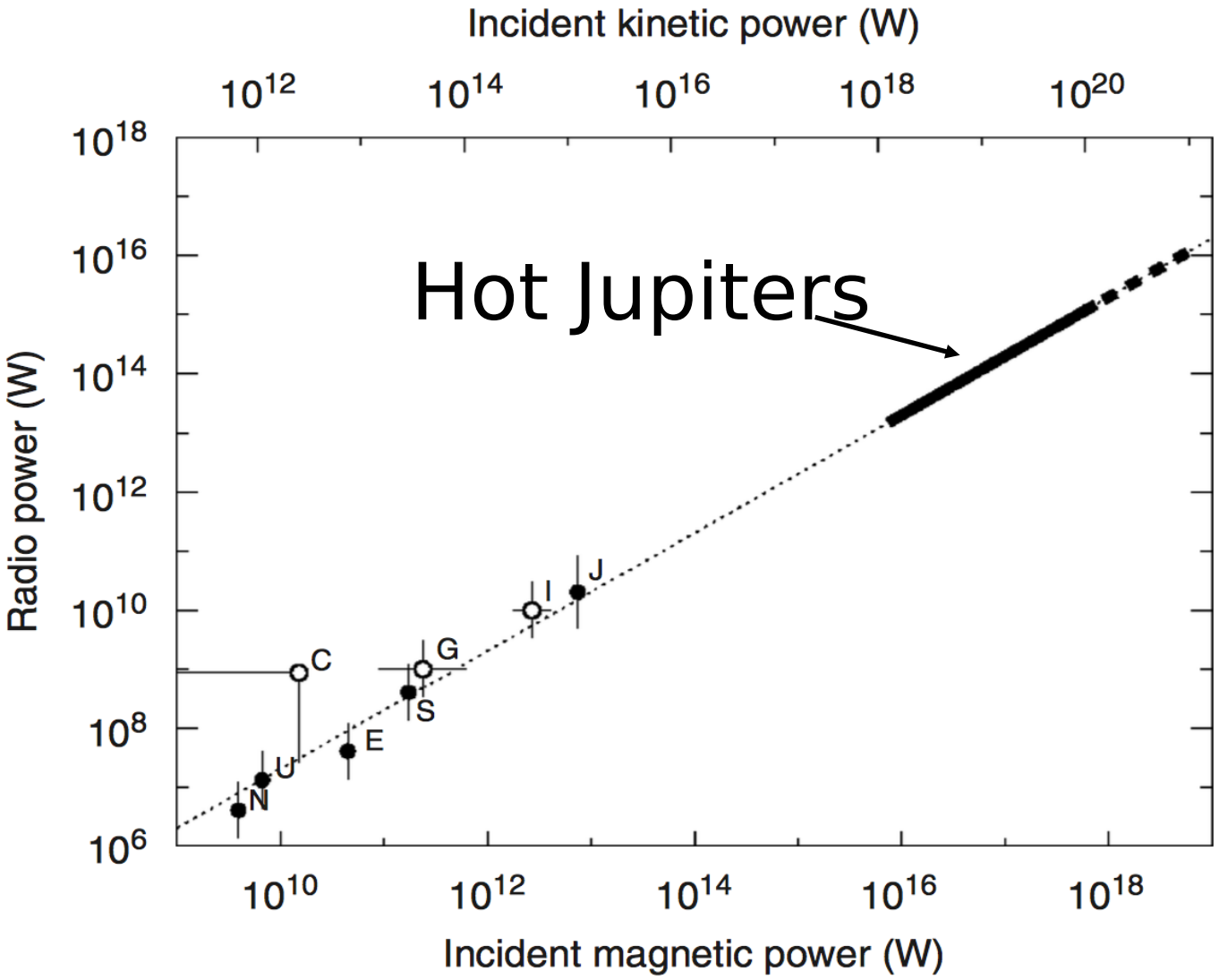


Can we detect similar emission for exoplanets?

PREDICTIONS FROM SOLAR SYSTEM



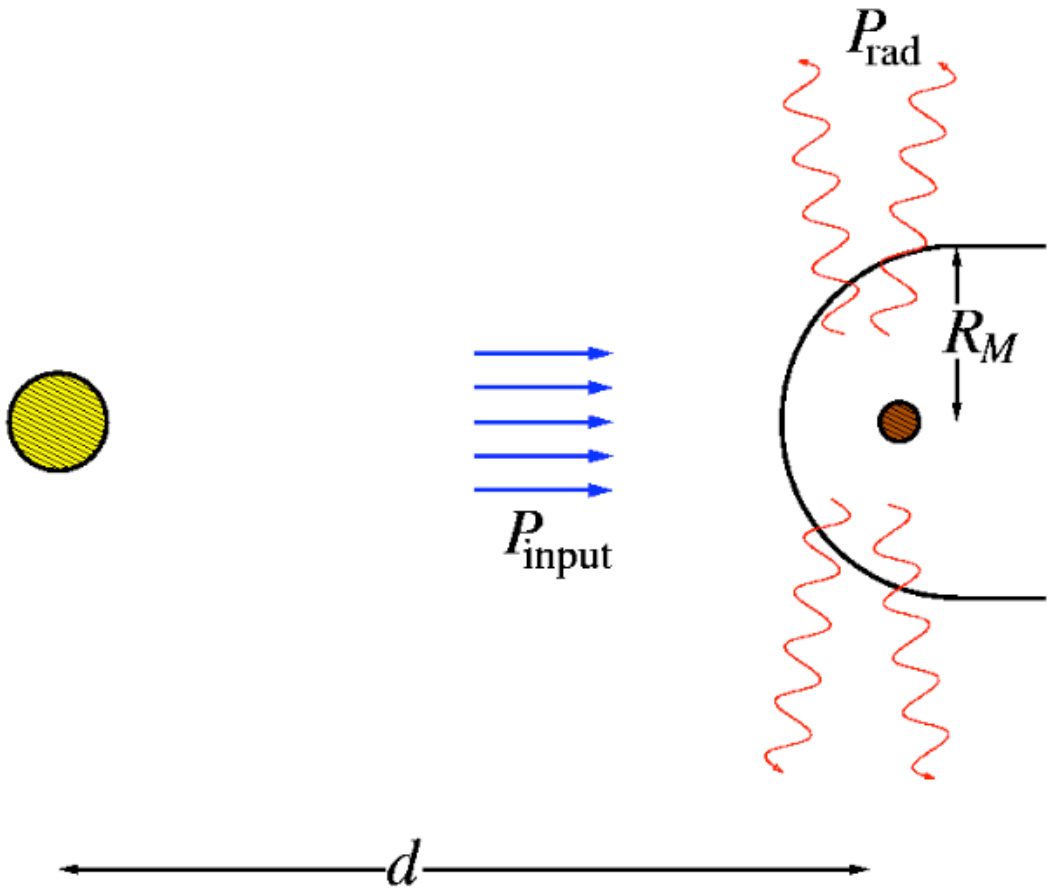
Zarka (2007)

RADIOMETRIC BODE'S LAW

$$P_{\rm K} \propto n_e v_{eff}^3 R_M^2$$

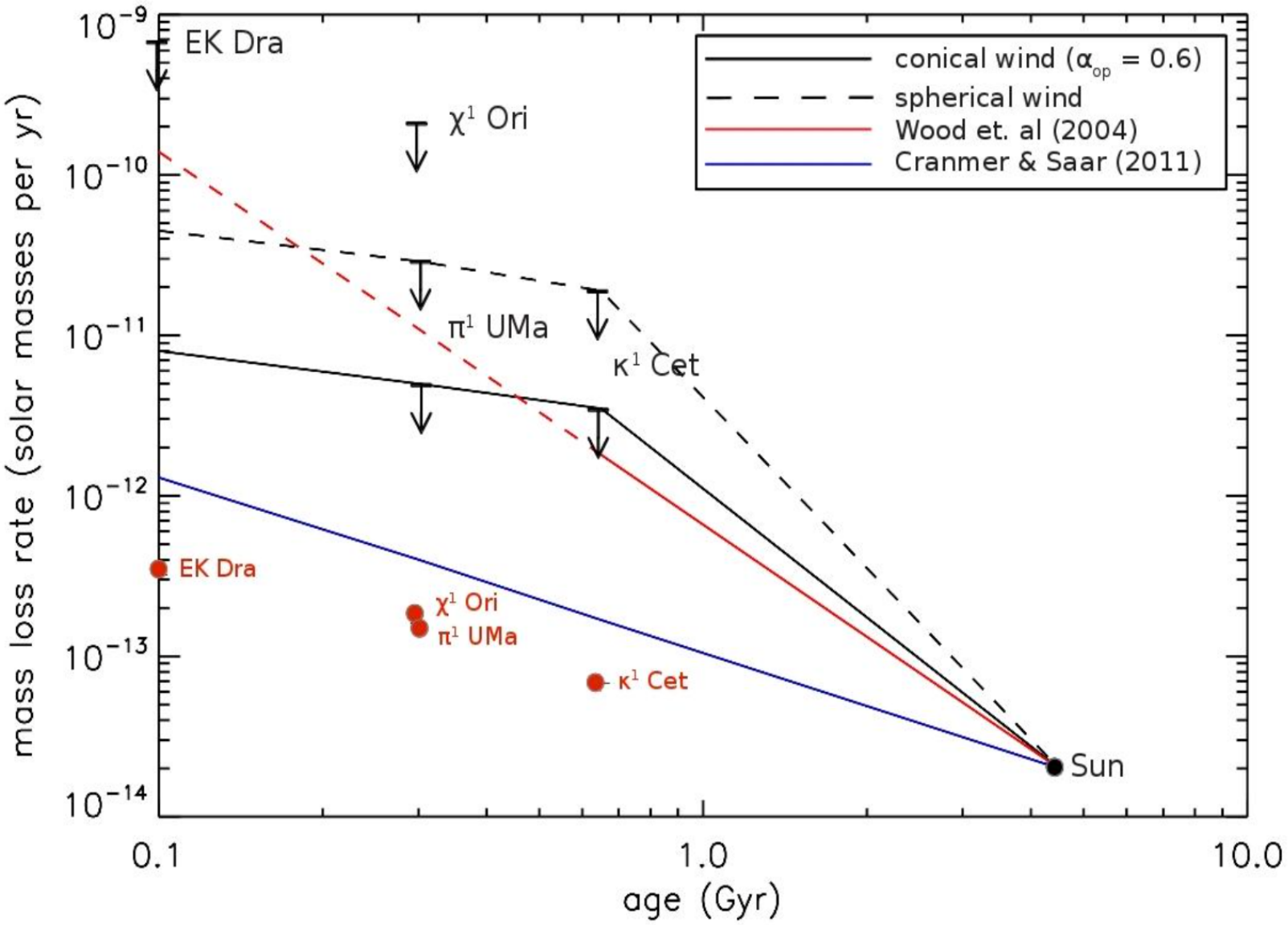
OR

$$P_{\rm B} \propto v_{eff} B_\perp^2 R_M^2$$



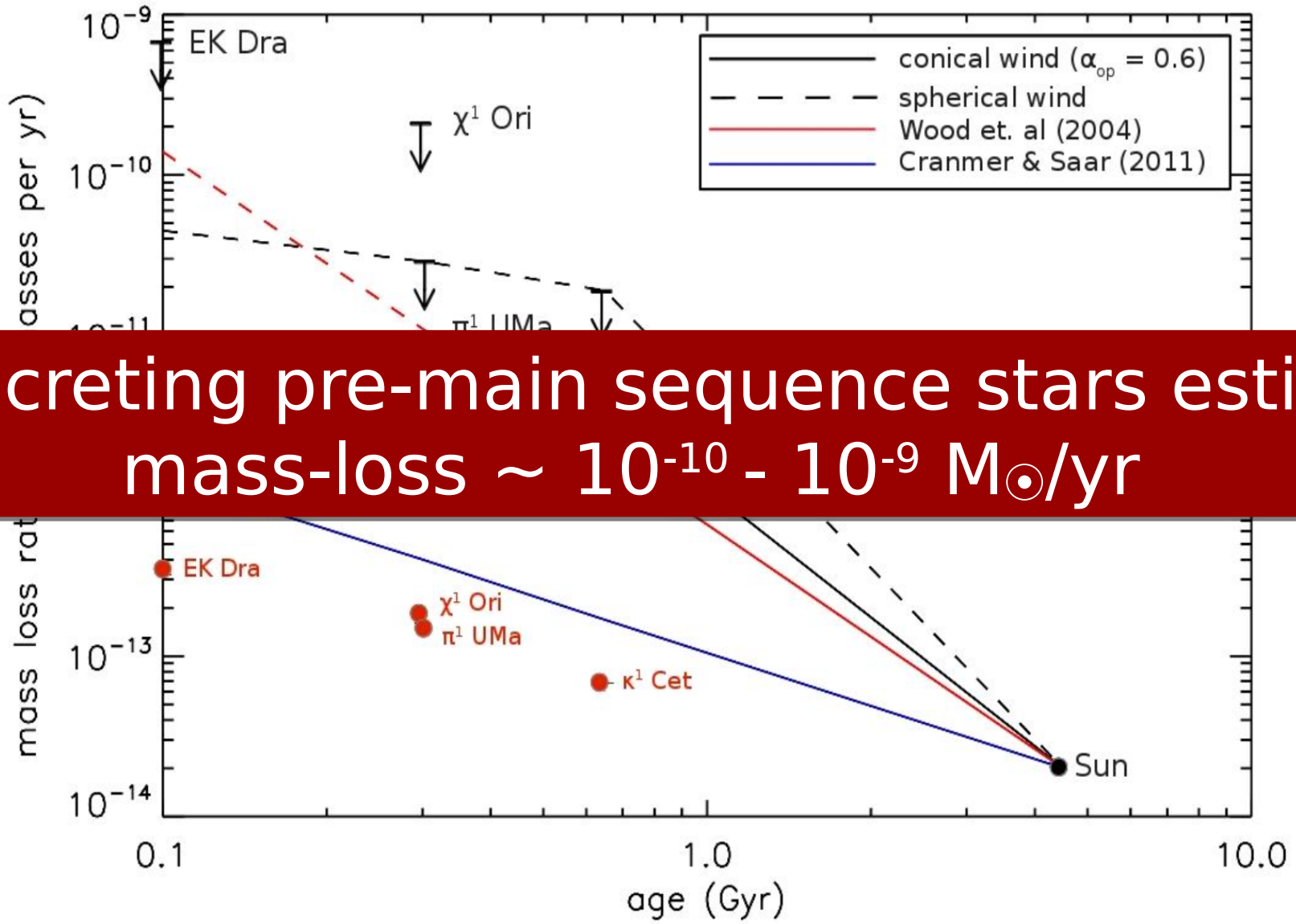
Stellar wind properties depend on stellar age.

MASS LOSS EVOLUTION WITH AGE



Fichtinger et al. (2017)

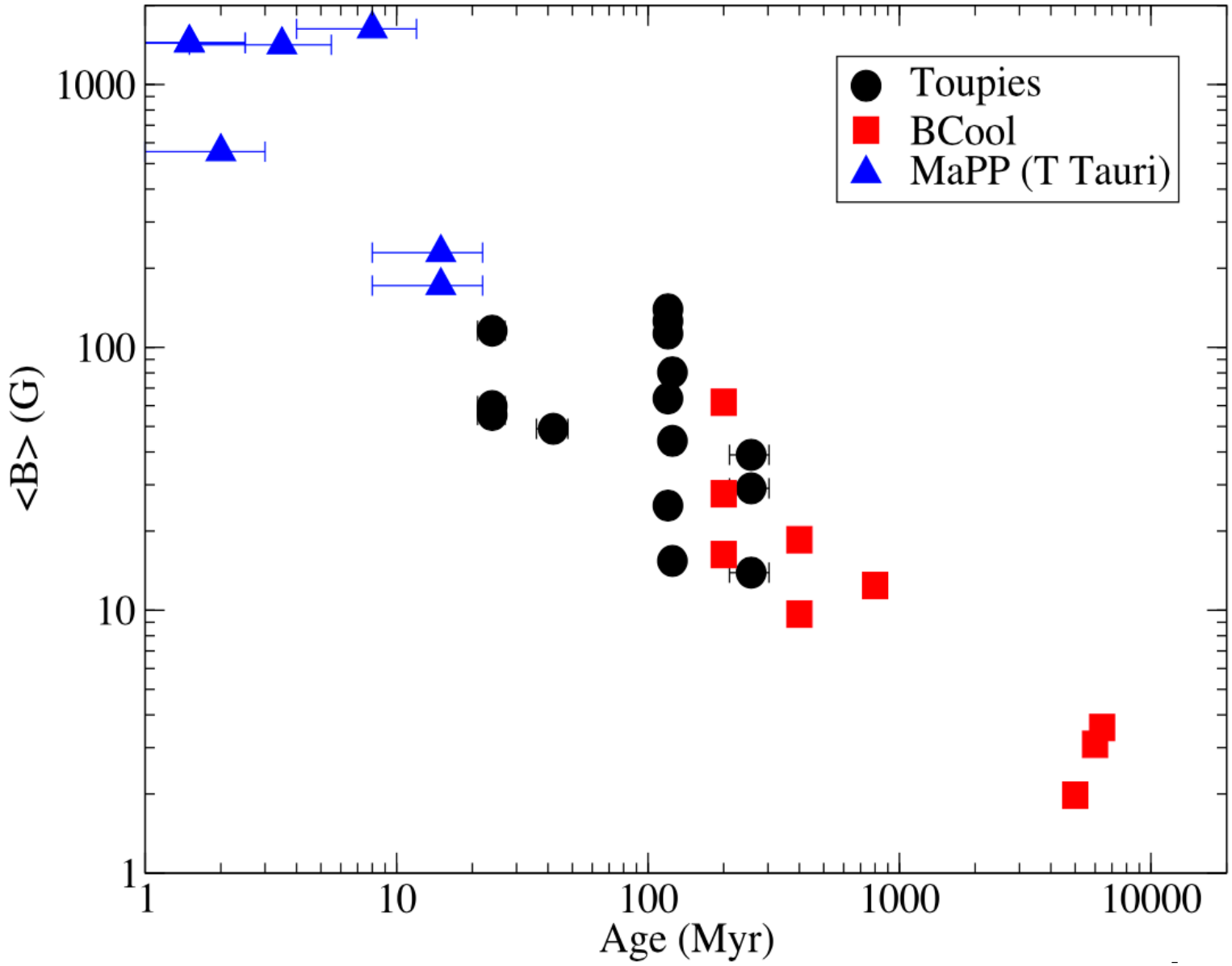
MASS LOSS EVOLUTION WITH AGE



Non-accreting pre-main sequence stars estimated mass-loss ~ 10^{-10} - 10^{-9} $M_\odot$/yr

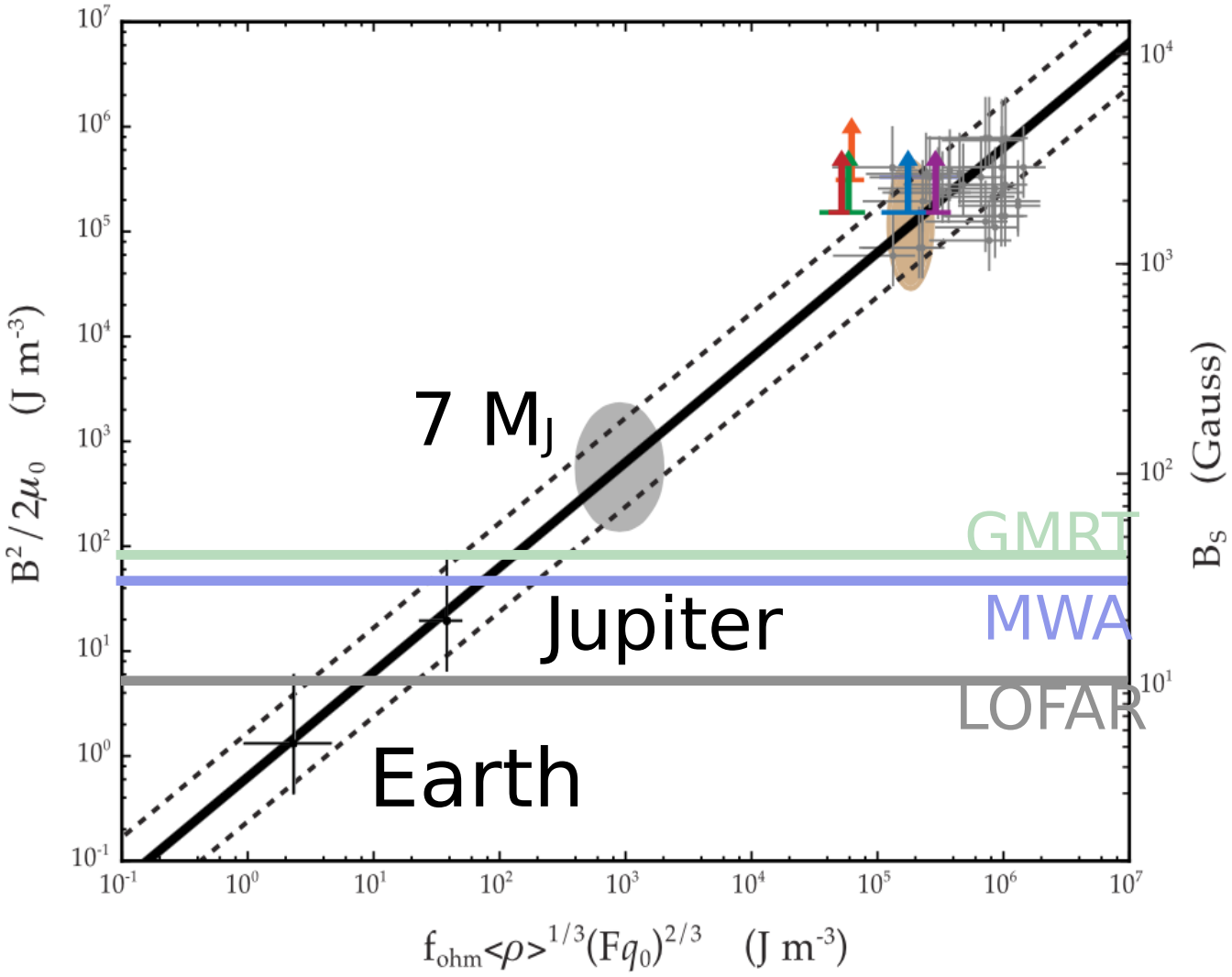
Fichtinger et al. (2017)

AGE DEPENDENCE FOR STELLAR FIELDS



Folsom et al. (2016)

WHAT ARE THE EXPECTED FIELD STRENGTHS?



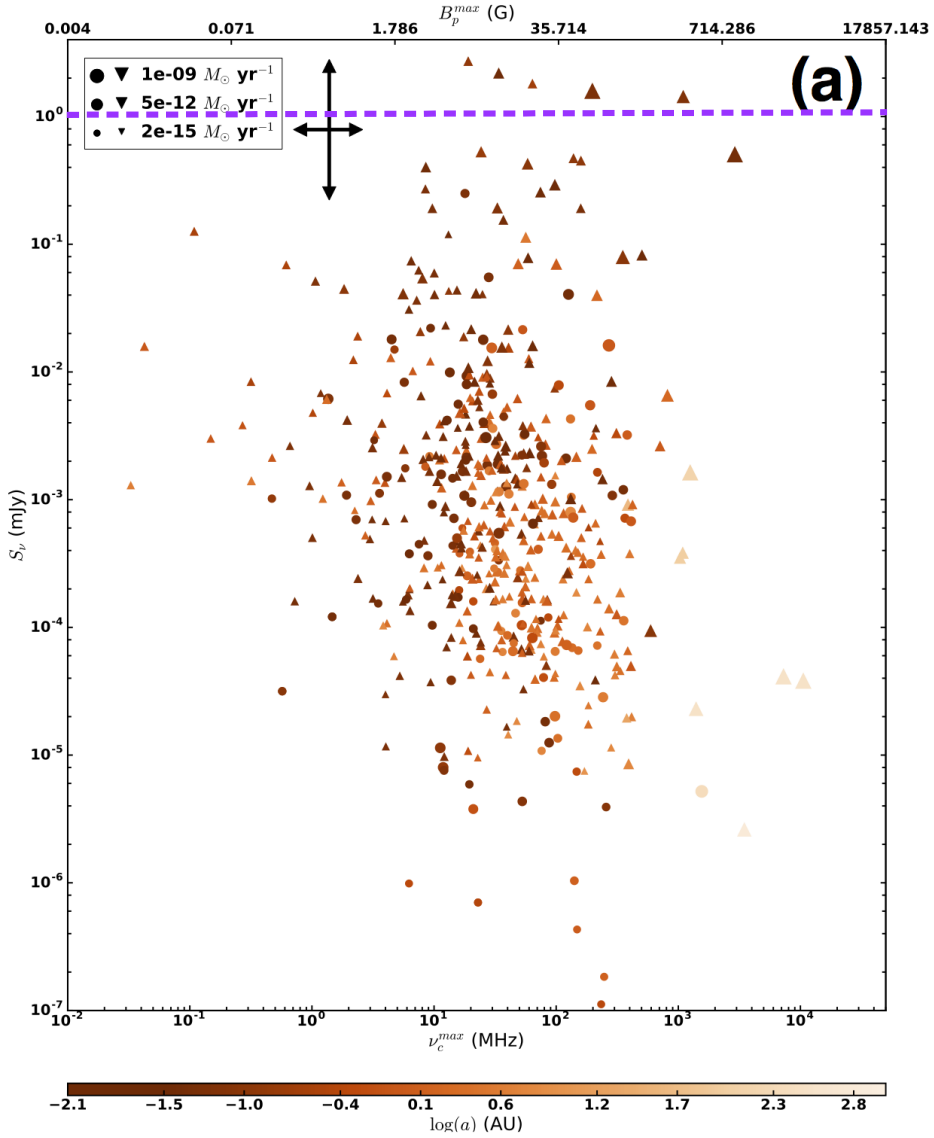
(Magnetic Energy)

(Internal Thermal Energy)

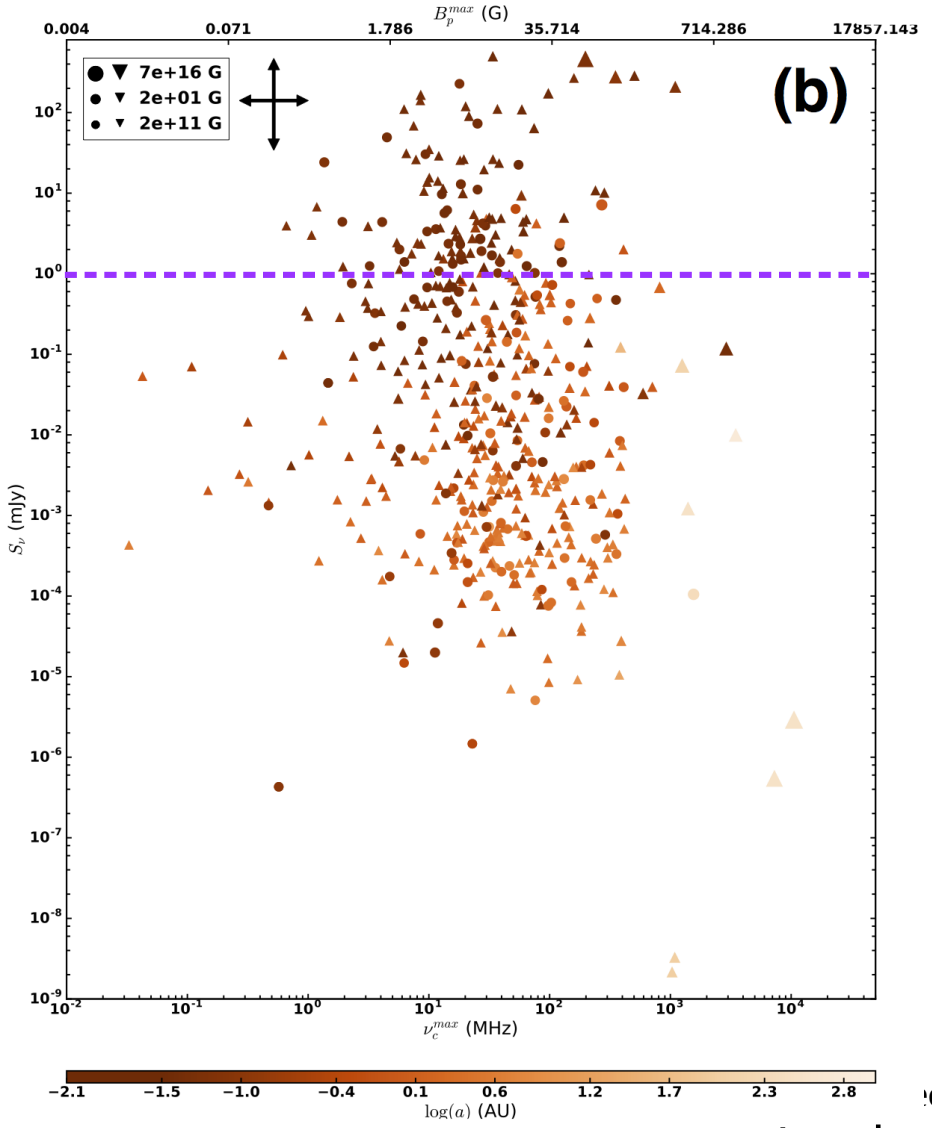
Kao et al. (2016)

PLANETS AROUND DWARF STARS (FGKM)

Kinetic



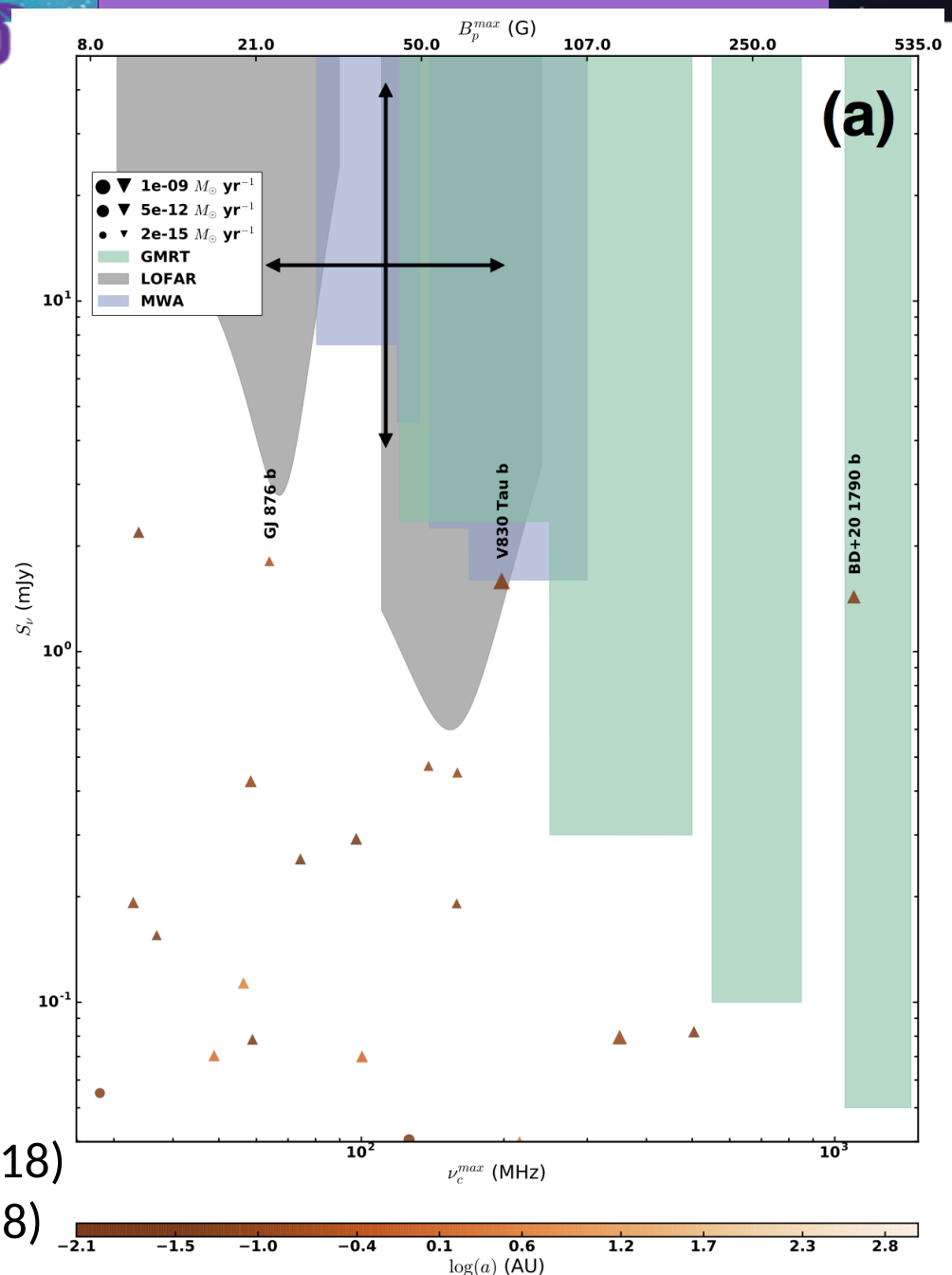
Magnetic

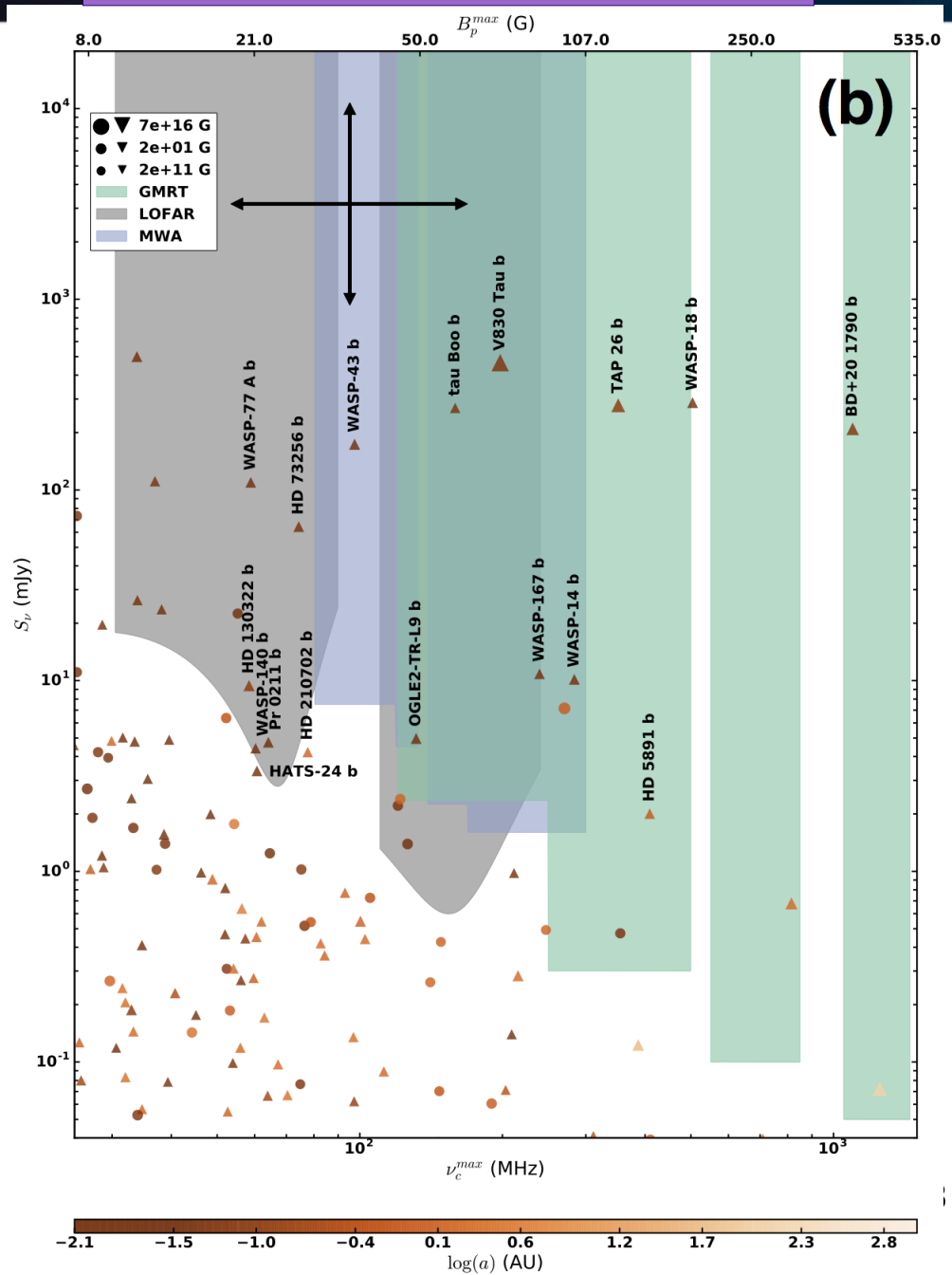


Lynch et al. (2018)

Kinetic

Magnetic

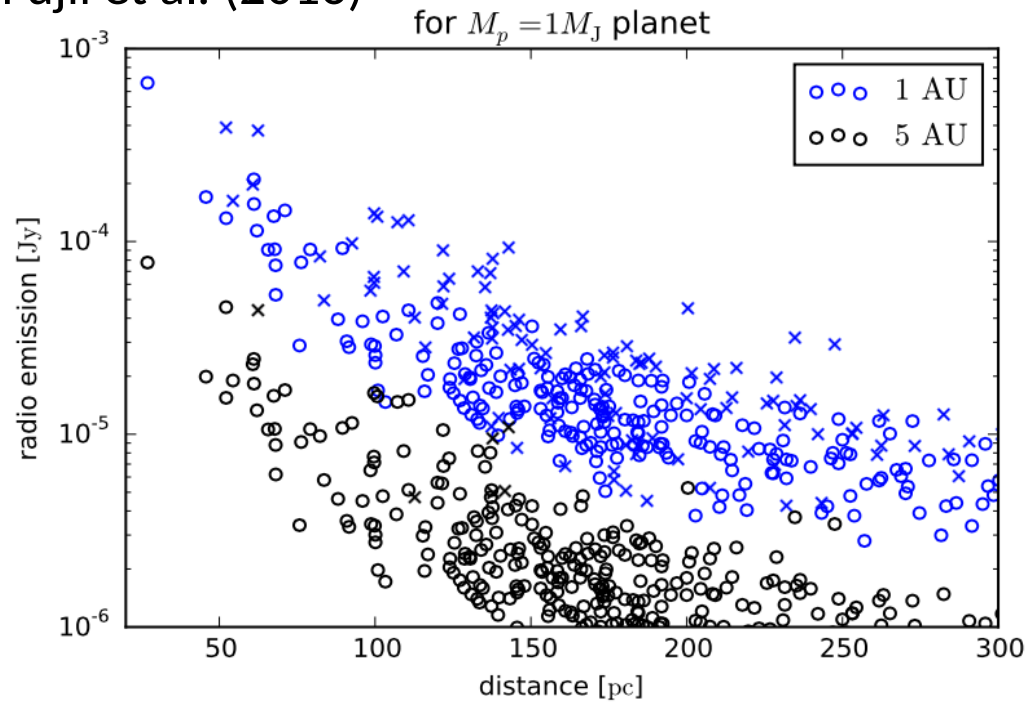


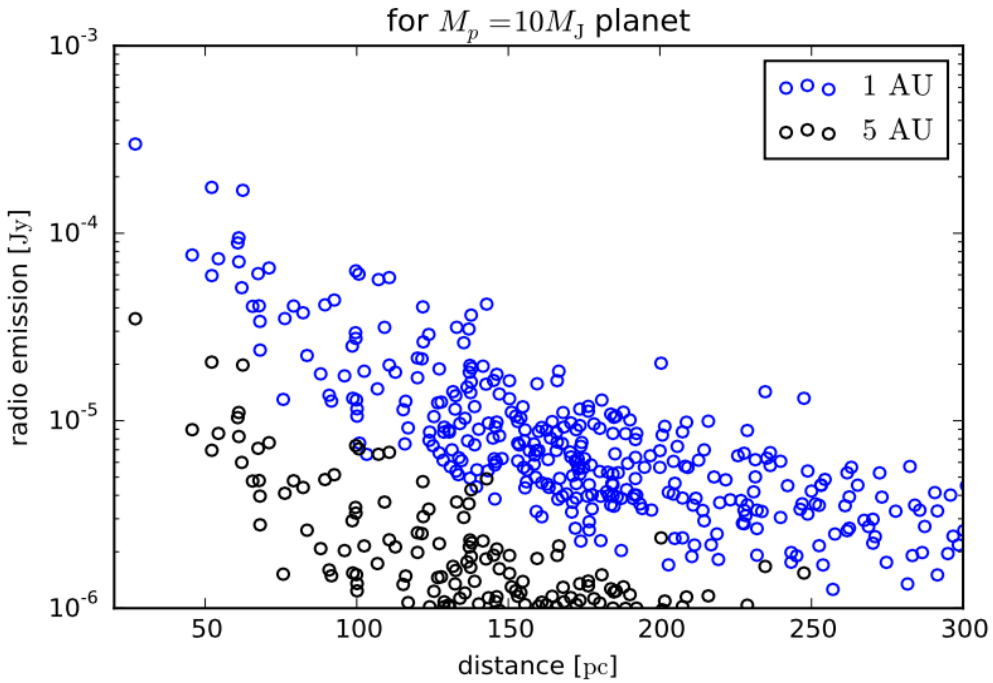


Lynch et al. (2018)
Lenc et al. (2018)

PLANETS AROUND EVOLVED STARS

Fujii et al. (2016)

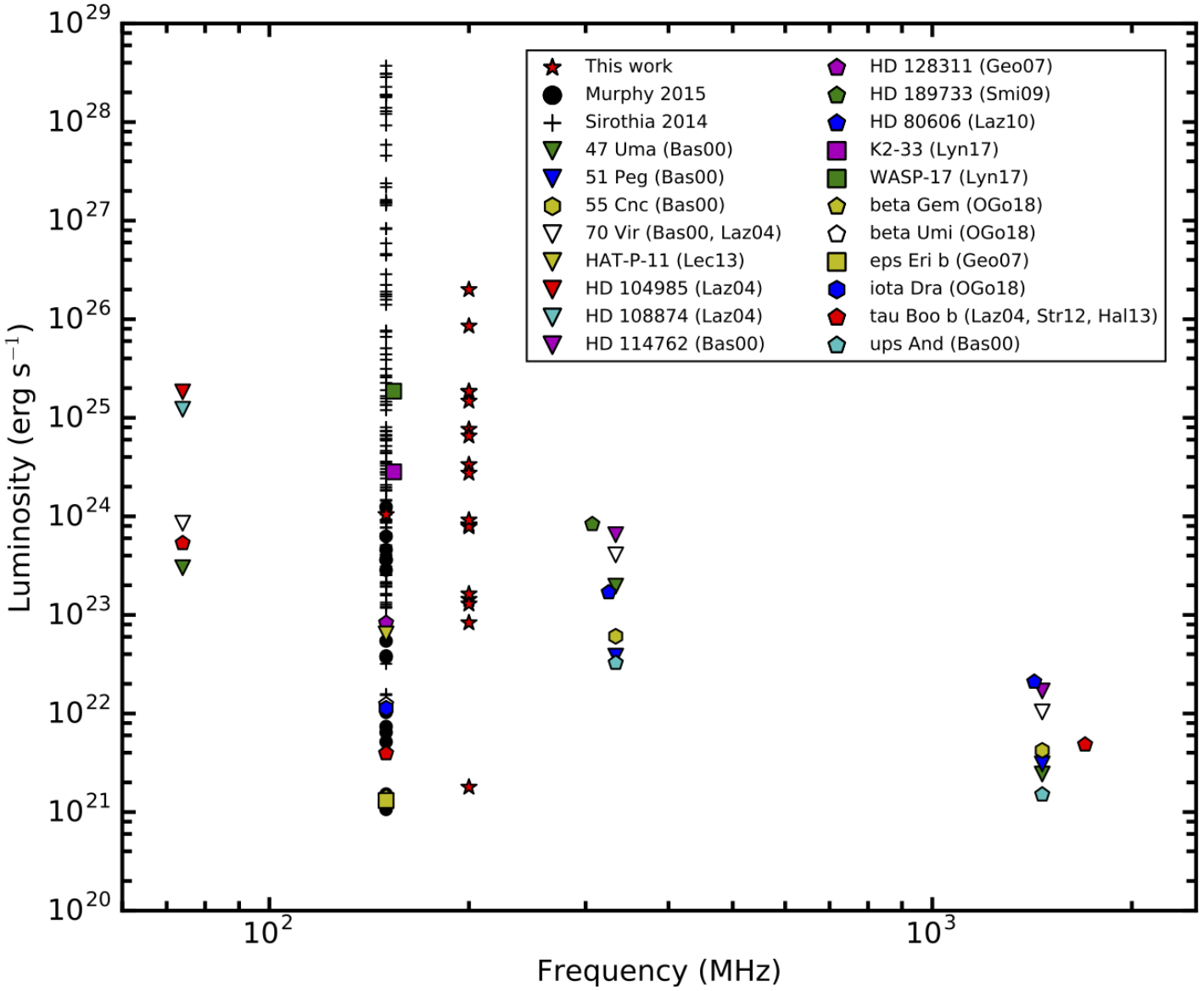




Hot Jupiters may be tidally locked > cannot sustain magnetic fields

Jupiters orbiting giant stars at ~1 au predicted to produce radio emission

LIMITS ON KNOWN EXOPLANETS



Lynch et al. (2018)

HOW TO EXPLAIN NON-DETECTIONS

Wrong frequency — focus on lowest observing frequency possible?

Radiometric Bodes Law might over predicts radio brightness — upgrades + SKA may help to rule out models.

Beaming — observations do not cover full orbits.

Best candidates for radio may not be the same as for optical techniques.

SUMMARY

Magnetised solar system planets produce radio emission — search for magnetised exoplanets at MHz frequencies

Detection of radio emission constrains: magnetic field strengths, rotational periods, and long term habitability.

Because of stellar wind dependence, best candidates are orbiting young active stars or giant branch stars.

Only non-detections; most involve targeted searches using known exoplanet systems.

Upper limits are explained by various factors (not just sensitivity).